

REMARKS

Claims 6-11 are presently pending in the application.

The Examiner has rejected all of the claims under 35 U.S.C. § 103(a) as being unpatentable over various combinations of prior art references, all based upon the primary combination of Japanese Published Patent Applications JP 11-214008 ("JP'008") in view of JP 11-3707 ("JP'707"). The U.S. counterpart of JP'008 is U.S. Patent No. 6,245,458 of Sotomura, which will be referred to in the following Remarks for convenience.

The Examiner contends in rejecting claims 6 and 7 that JP'008 discloses a lithium battery comprising a positive electrode and a negative electrode, wherein the positive electrode comprises a mixture of elemental sulfur powder, a metal complex of an organic sulfur compound having a thiol or thiolate group, and a conductive polymer. The Examiner acknowledges that JP'008 does not expressly teach that the negative electrode contains a composite nitride of the formula $\text{Li}_{3-x}\text{M}_x\text{N}$. However, the Examiner notes that the Abstract of JP'707 discloses a secondary battery comprising a negative electrode comprising a nitride of the formula $\text{Li}_{3-x}\text{M}_x\text{N}$, wherein x and M are the same as in claim 6.

The Examiner concludes that the invention as a whole would have been obvious to one skilled in the art because the disclosure of JP'707 would motivate the artisan to use a nitride of the formula $\text{Li}_{3-x}\text{M}_x\text{N}$ as the negative electrode active material of JP'008. The Examiner notes that the Abstract of JP'707 teaches that deterioration of battery characteristics at high temperature storage times can be retarded by using this active material and argues that this would be the motivation to use this nitride as the negative electrode active material of JP'008.

In rejecting claims 8-11, the Examiner adds various other prior art references to the combination of JP'008 in view of JP'707 to teach various other features in these claims. However, the basic rejection is the same as applied to claims 6 and 7 above.

These rejections are respectfully but strenuously traversed for the reasons set forth in detail below.

While not agreeing with the Examiner's contentions and arguments with respect to the tertiary references relied upon in rejecting claims 8-11, these tertiary references will not be further discussed in this response, since they have already been discussed in detail in the Amendment filed June 11, 2003 in response to the previous Office Action. Instead, this response will focus primarily on the impropriety of the basic combination of JP'008 in view of JP'707

which the Examiner uses as the basis for all of the rejections, as summarized above with respect to claims 6 and 7.

First of all, it should be pointed out again that in the field of batteries, it is difficult to predict whether the combination of a particular positive electrode with a particular negative electrode used in a specific system will yield a useful battery. That is, merely because a particular positive electrode and a particular negative electrode are known in the art of batteries does not mean that they can be successfully combined in a specific battery system with any reasonable expectation of success.

In the present case, the only reason that the Examiner has given for combining the negative electrode of JP'707 with the positive electrode of JP'008 is that the Abstract of JP'707 teaches that "deterioration of battery characteristics at high temperature storage times can be retarded" by using this active material, and that the artisan would be motivated to use this nitride as the negative electrode active material of JP'008. However, this reason is rather illogical since deterioration of battery characteristics at high temperature storage times is not a problem particularly recited in JP'008. Instead, JP'008 is particularly concerned with loss of characteristics such as large capacity and high energy density during the charging and discharging cycle at room temperatures (see col. 2, lines 33-44 of Sotomura).

In any event, the Examiner has cited no reasons for a reasonable expectation of success in making the proposed combination of these two electrodes, and due to the unpredictable nature of this field, the best that can be said of this combination is that it might be "obvious to try." However, this is not a proper standard for obviousness under 35 U.S.C. § 103. In order to establish a *prima facie* case of obviousness, there must be both motivation to make the combination and a reasonable expectation of success in making the combination. Neither of these is present in the current rejections.

Second, some background to the present invention may be helpful. One of the reasons why a non-aqueous electrolyte battery using lithium as an active material has higher performance than an aqueous solution electrolyte battery is that the non-aqueous electrolyte battery generates higher voltage. The aqueous solution electrolyte battery generates voltage of at most 1.5 V because electrolysis of water occurs. In contrast, currently used non-aqueous electrolyte batteries using lithium generate a voltage of 4 V or higher without decomposing the electrolyte.

The fact that generated voltage is high means that even a single cell generates a high driving voltage and provides high battery energy. The high battery energy means that the product of the quantity of electricity of the electrode and the generated voltage is large. That is, in comparison between electrodes having the same quantity of electricity, higher battery energy is obtained when higher voltage is generated. The higher the battery energy, the more advantageous the battery in operating electrical equipment.

Further, if the battery energy can be improved without changing the volume and weight, the energy density of the battery will be improved. Such improvements in energy density have been exploited in various types of portable electronic equipment, such as cellular phones, notebook computers, and video cameras, using lithium ion batteries as a power source. Indeed, these products place significant emphasis on high voltage, high energy density and long life of the battery.

More recently, there has been a tendency in the industry of portable electronic equipment to reduce the drive voltage for the equipment, so that the equipment is usable with a voltage ranging from 2 to 2.5 V (see paragraph bridging pgs. 1 and 2 of the present specification).

The object of the present invention was to develop a lithium battery capable of exhibiting high energy density at low voltage. In order to accomplish this goal, it was necessary to solve problems traditionally occurring with lithium batteries, namely, pre-processes of intercalation and de-intercalation of lithium to or from the electrodes reduce the capacity, difficulties with capacity balance matching between positive and negative electrodes, and solving risks resulting from high voltage (see page 12, 1st full paragraph of specification).

More specifically, in lithium batteries, lithium is transferred between the positive and negative electrodes during charging and discharging, and it is preferable that initially only one of the electrodes contains lithium (as in claims 6 and 7) so that charging and discharging are possible without the presence of excessive, wasteful lithium. As taught in the specification, for prior art batteries which contain a combination of a sulfur-containing composite electrode and a carbon material, since neither electrode contains lithium, a process of intercalating lithium into one of the electrodes is needed during manufacture. Conversely, in batteries having a negative electrode containing a lithium-containing composite nitride and a positive electrode of LiCoO_2 , a process for deintercalating lithium from one of the electrodes is needed during manufacture. Further, in both types of prior art batteries, it may be necessary to reduce the lithium content of

one of the electrode materials in the battery if there is too large a difference between the capacity densities of the two electrodes, thus not maximizing the high capacity characteristics.

However, Applicants have developed a battery in which neither of these intercalation or deintercalation processes is necessary, a battery in which both the positive and negative electrodes exhibit high energy density so that the combination is well balanced and the resulting battery exhibits high energy density. More specifically, Applicants have developed a battery which utilizes a lithium-containing composite nitride as a negative electrode and a composite electrode composition as a positive electrode which contains sulfur or lithium-containing sulfur and a metal complex of an organic sulfur compound (M-SS). Applicants have found that the combination of sulfur or lithium-containing sulfur and M-SS in the positive electrode results in a battery having a larger capacity than one with a composite electrode which contains only an organic sulfur compound (SS) and polyaniline (PAn).

Further, in one embodiment, a battery containing a combination of M-SS, SS, and PAn yields high utilization, high reversibility, and high electric potential. The M-SS as a component of the composite electrode functions as an active material, and also prevents the SS and/or SS/PAn complex from dissolving in the electrolyte and dissipating from the positive electrode. Accordingly, batteries containing M-SS exhibit longer charge/discharge cycle life and a flatter voltage than those containing only SS and PAn. Further, Applicants have found that the use of a lithium-containing sulfur compound prevents a decrease in capacity and degradation of the cycle characteristics due to sulfur-sulfur aggregation or isolation of sulfur, which may occur in electrodes containing only sulfur. Accordingly, the claimed batteries, which may be produced from electrodes without the need for lithium intercalation or deintercalation processes, exhibit high safety, good capacity balance, low voltage, and high density characteristic.

In a preferred embodiment, recited in claims 6 and 7, initially, the positive electrode contains sulfur and a metal complex of an organic sulfur compound (M-SS) but no lithium, whereas the negative electrode contains lithium in the form of a lithium-containing composite nitride. Because only one of the electrodes initially contains lithium, charging and discharging cycles are possible without the presence of excessive, wasteful lithium; no processes for intercalation or deintercalation of lithium are needed.

In a second preferred embodiment, recited in claims 8-11, the negative electrode contains a mixture of a material containing no lithium originally, such as an alloy or metal oxide, and a

material containing lithium, such as a lithium-containing composite nitride. Using these components together optimizes the content of lithium in the negative electrode. As a result, lithium deintercalated from the lithium-containing composite nitride is not directly intercalated into the positive electrode, but is captured into the alloy or metal oxide in its vicinity, thus solving problems of adjusting lithium content, e.g., those relating to capacity and voltage.

Thirdly, turning to references JP'008 and J'707, both of the references utilize electrodes generating low voltages as compared with the electrode of the present invention. Thus, the positive electrode of JP'008 generates lower voltage than that of an LiCoO_2 electrode, while the negative electrode of JP'707 generates higher voltage than that of a carbon electrode. Accordingly, both of the references use electrodes generally known in the art as counter-electrodes, in order to retain the generated voltage as high as possible, in view of the prior art desire to obtain higher battery energy by generating as high a voltage as possible. See for example Sotomura, col. 3, lines 49-51 (a high voltage of not lower than 3 V) and col. 11, lines 42-45 (batteries charged and discharged in a range of 1.0 to 4.35 V).

A person skilled in the art would not combine the electrodes of the two cited references in order to obtain a battery generating low voltage. Even if the skilled person had a thought of such a combination, he would not have had any expectation of success, since it is irrational to claim the advantage of having high energy density while at the same time having the disadvantage of low voltage generation. Moreover, such a battery could not take the place of lithium ion batteries for driving portable electronic devices now in use, because the voltage would not conform to that of batteries currently used in such equipment.

Fourth, in order to calculate the advantage of the claimed energy density, it is necessary to optimize volumes and weights of the electrodes, thickness and weight of the separator, weight of the electrolyte and thickness and weight of the current collector in view of the intended battery volume. That is, in order to optimize these elements of the battery, one needs to forecast that even if the voltage of the battery is decreased from 4 V or higher to as low as 2.4 V, the battery can be put on the market in view of the current trend toward low IC driving voltage. Further, there is also the required conjecture that the claimed combination of electrodes will definitely increase the energy density as a whole, not to mention the effort required to confirm the conjecture by actually fabricating the battery. Therefore, in view of all of the factors which must

be considered, it can not be concluded that one of ordinary skill in the art would arrive at the claimed invention merely by combining the two known electrodes of JP'008 and JP'707.

Finally, it is noted that both of the cited references are owned by the same Assignee as the present application, namely Matsushita Electric Industrial Co., Ltd. Applicant has found that the electrodes used in the cited references have some problems, so that they are not being commercially used. Therefore, it is even more unlikely that a person skilled in the art would be led to the thought of combining such problematic electrodes. In contrast, the batteries according to the presently claimed invention have been shown to have excellent volume/weight energy density at low voltage (2.4 V) and high capacity maintenance ratios (see particularly Tables 1 and 4 at pages 32 and 41 of the present specification).

Although only references JP'008 and JP'707 have been specifically discussed above, it is submitted that none of the remaining references in any way affects the attempted combination of these two references or makes up for any of the deficiencies of this combination. Accordingly, reconsideration and withdrawal of the rejections and an early Notice of Allowance are respectfully requested.

Respectfully submitted,

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